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Filling Polyethylene Film Bags With CITRUS FRUIT

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Transportation and Facilities Research Division

in cooperation with the
FLORIDA AGRICULTURAL EXPERIMENT STATION

PREFACE

This report is based on research which is part of a broader project to develop more efficient work methods, equipment, and facilities for the handling and preparation for market of citrus fruits and vegetables at Florida shipping points. The data obtained were used to evaluate the engineering and economic aspects of four methods of bagging citrus fruit in polyethylene film bags.

The work was conducted under the supervision of Earl K. Bowman, industrial engineer, and Joseph F. Herrick, Jr., marketing research analyst, of the Handling and Facilities Research Branch, Transportation and Facilities Research Division, Agricultural Marketing Service, U. S. Department of Agriculture.

The Roper Growers Cooperative, Winter Garden, Fla., developed and made available for study the channel-type bagger described in the report as a mechanical aid for bagging citrus. The following Florida citrus packinghouses made their plant facilities available for this study: Alcoma Packing Company, Inc., Lake Wales; Brooksville Citrus Growers Association, Brooksville; Herman J. Heidrich and Sons, Lockhart; Newbern Groves, Tampa; Spada Fruit Sales Agency, Inc., Thonotosassa.

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Washington, D. C. July 1963

SUMMARY

Citrus fruit packinghouses handling an annual volume of 1,600,000 5-pound bags of oranges can save up to $3,525 a year by switching from manual methods of filling bags to a machine that counts the fruit electronically and fills each bag with a predetermined number of fruit. This saving is based on a crew of 13 workers using manual methods at bin or roll-board packing stations and a crew of 7 workers using mechanical equipment.

Four methods of bagging citrus fruit were studied: Manually filling the bags; using the machine that filled the bags by count; using a machine that cut off the flow of fruit as soon as the bag of fruit reached the desired weight; using a sloping channel that was wide enough for a single row of fruit and could be adjusted to hold the number of fruit needed to fill one bag.

Manual bagging was most economical for small packinghouses (annual volume of less than 399,200 5-pound bags); the new channel-type bagger was most economical for medium-size packinghouses (between 399,200 and 1,145,840 bags); and the count bagger was most economical for large packinghouses.

With the channel-type bagger, five workers filled bags and three other workers closed the bags and packed them into master containers. At a volume of 500,000 bags per crew, the saving was about $200 to $600 a year more than with the other systems studied.

At a volume of 200,000 bags a year, the saving from packing bags manually was about $500 more than the saving with the system that was the second most economical.

FILLING POLYETHYLENE FILM BAGS WITH CITRUS FRUIT

by William G. Grizzell, industrial engineer
Transportation and Facilities Research Division
Agricultural Marketing Service

OBJECTIVES OF STUDY

Interest in shipping Florida citrus fruit in polyethylene bags packed for consumers increased during the late 1950's and early 1960's. During the 1958-59 shipping season, 11,598,868 polyethylene bags of oranges and grapefruit were shipped from Florida. 1/ In 1959-60 the number of polyethylene bags nearly doubled; 21,405,956 bags of oranges and grapefruit were shipped. In this same period of time, there was little change in the number of mesh bags shipped. In the 1960-61 season, the shipments of polyethylene bags remained nearly the same, at 21,262,820, while the shipments of mesh bags decreased from 33 million to less than 22 million.

Oranges and grapefruit were packed in 5- and 8-pound sizes of polyethylene bags and in 5-, 8-, and 20-pound mesh bags.

Time and work sampling studies of bagging operations were made by the Agricultural Marketing Service in several Florida packinghouses, as a part of an overall engineering-economic study of citrus packinghouses to develop improved work methods, equipment, and facilities.

CITRUS BAGGING OPERATIONS

Bags for consumers were usually filled by counting the fruit as it was placed in the bags, with the number of fruit depending on both the size of the fruit and the bag. A supervisor spot-checked bag weights to ascertain the number of fruit that must be placed in each bag. Weight of the bag was controlled by varying the number of fruit in each bag and by adjusting the mechanical sizer that delivered fruit to the bagging stations to increase or decrease the average size of the fruit.

Individual belt and roll sizers, used on most packing bins for place-packing 1 3/5- and 4/5-bushel boxes, were also used for manually filling bags. With the advent of roll-board place-packing and mechanical packing systems,

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1/ All data on volume by type of container were taken from the annual reports of the Citrus and Vegetable Inspection Division, Florida Department of Agriculture.

several packinghouses started using central sizers to size fruit for bagging as well as for place-packing in boxes. [2] Some systems of mechanical bagging require a second sizer, in addition to the main central sizer, to size the fruit accurately before bagging.

When bags were filled manually, each packer also closed the bags and packed them in master containers. When bags were filled with the aid of mechanical devices, a crew of seven to nine workers synchronized their efforts to fill and close bags and to pack them in master containers.

The arrangement of equipment for mechanical bag filling was similar to that shown in figure 1. The fruit-feed, or return-flow belt delivered citrus fruit from the sizer to the bagging units. In most installations, all excess fruit left on the belt was returned to the head of the conveyor line into position for redelivery to the bagging units.

Filling Bags

Four ways of bagging citrus fruit were studied: (1) Filling bags manually; (2) using an electronic machine that counted the fruit and automatically put a preset number of fruit in each bag; (3) using a machine that automatically cut off the flow of fruit when the bag of fruit reached a certain weight; and (4) using a channel-type device that collected the number of fruit needed for a bag.

Whether polyethylene bags were filled by count or by weight, the bag was filled with fresh citrus fruit that weighed slightly more than the net weight marked on the bag. The extra weight allowance was to insure that the consumer would receive the weight of fruit marked on the bag after normal fruit shrinkage and small weighing variations.

Filling Bags Manually

Bags were filled manually at the regular roll-board or bin-packing station used for packing wirebound boxes or corrugated cartons. The worker held the top of the polyethylene bag with one hand and filled it with the other hand by picking fruit from the roll board or the bin one or two at a time and dropping them into the bag. The worker closed the filled bags by hand with a taping device and placed them into a master container beside the filling station.

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[2] A roll-board place-packing station is a sloping board on which the fruit rolls down in one layer to a stopboard, which retains the fruit until the packer picks it up. (Bowman, Earl K., and Yost, G. E. "An Improved Place-Packing Station for Citrus Fruit," U. S. Dept. Agr. AMS-447, 24 pp., illus.) When a central sizer is used, sized fruit is carried on a conveyor belt from one sizer to the various packing stations.

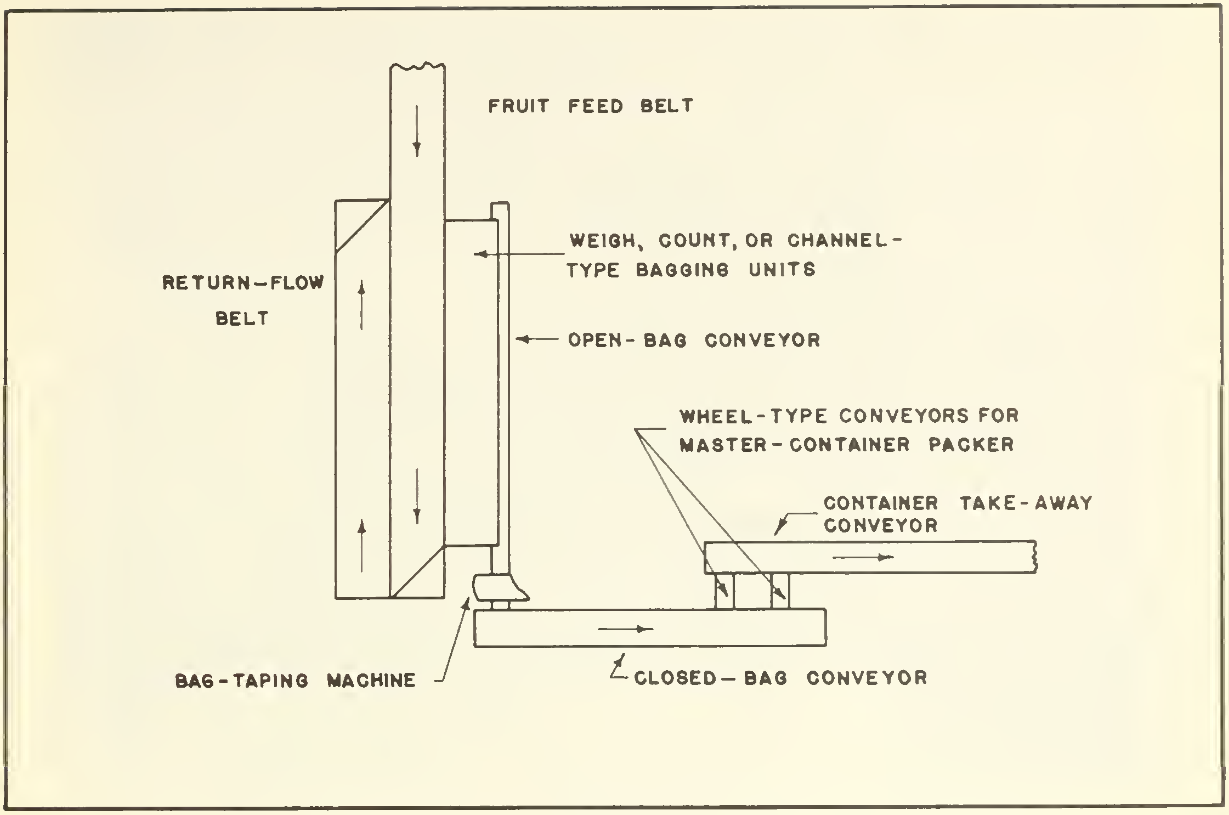
FRUIT FEED BELT
WEIGH, COUNT, OR CHANNEL-TYPE BAGGING UNITS
RETURN-FLOW BELT
OPEN-BAG CONVEYOR
WHEEL-TYPE CONVEYORS FOR MASTER-CONTAINER PACKER
CONTAINER TAKE-AWAY CONVEYOR
BAG-TAPING MACHINE
CLOSED-BAG CONVEYOR

Figure 1.--General layout of equipment for a crew of workers to fill, close, and pack bags into master containers.

Machine for Filling Bags by Count

The machine that filled bags by counting the fruit electronically required a worker at each bagging unit. The bagging supervisor set the dial on the machine to the number of fruit needed to fill one bag to the desired weight. The machine operator held a bag under the fruit spout and touched the foot switch, and the machine automatically counted the number of fruit preset on the dial (fig. 2). When the machine stopped counting, the operator set the filled bag on an open-bag conveyor (one specially designed to hold an open bag upright) for delivery to a machine that closed the bags. The operator then picked up an empty bag from her lap, held it under the spout, and the cycle was repeated. The operator placed about 30 empty bags in her lap at one time from a bag holder beside her chair.

The workplace observed in this study was arranged so that the worker had to be seated to operate the machine (fig. 3). A chute extended down from the counting mechanism of the machine toward the operator. The open-bag conveyor was located behind the chute. After filling the bag, the operator leaned over and set the bag upright on the conveyor.

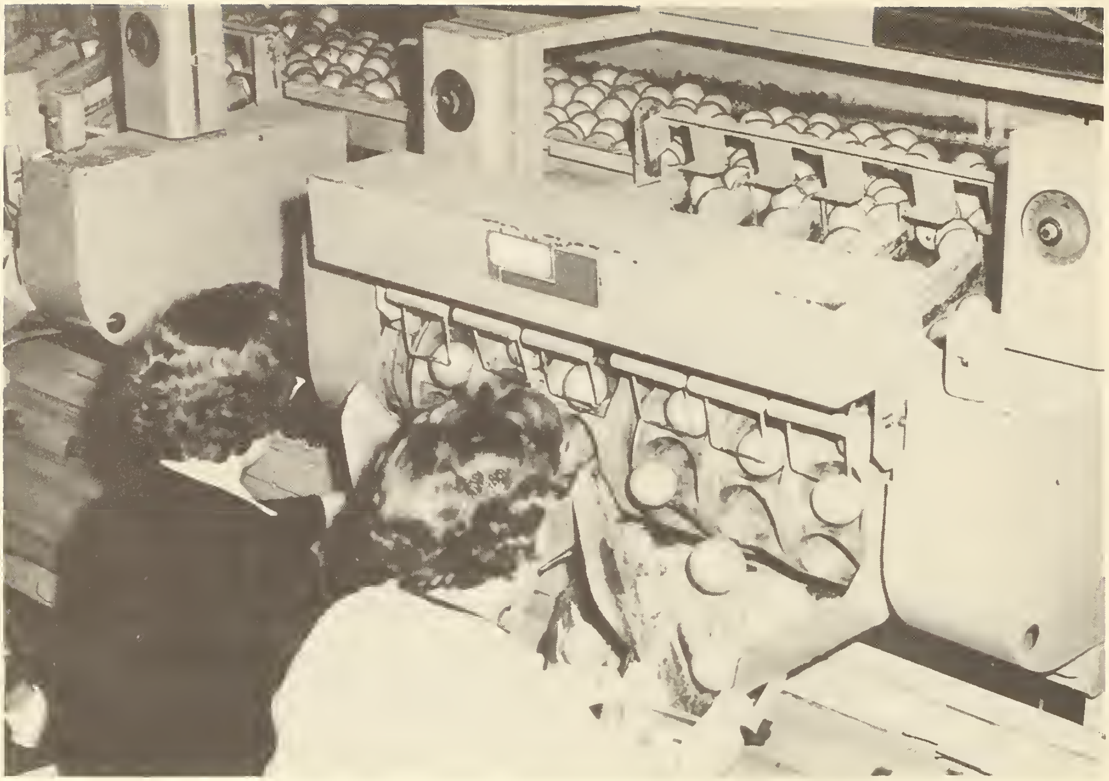

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Figure 2.--Workers filling polyethylene bags with a machine that fills the bags by count.

With this machine one worker could fill from 500 to 625 5-pound bags per hour, depending on the size of the fruit.

Machine for Filling Bags by Weight

The machine for filling bags by weight had two filling units for each worker; the units were mounted in pairs on the fruit distribution belt (fig. 4).

The worker fastened a bag to the hopper with special clamps, which held the top of the bag under the weighing head, and opened a gate on the unit to allow fruit to drop into the bag from the return-flow fruit-feed belt. When the bag was filled to the desired weight, an automatic cutoff switch closed the gate. The worker removed the filled bag from the clamps and set it on an open-bag conveyor for delivery to the bag-closing machine. While one unit was filling a bag, the operator removed the filled bag from the other unit and replaced it with an empty bag.

The worker had to stand to operate the machine. A shelf below and between two of the weighing units held the supply of empty bags. The open-bag conveyor was below the weighing units, fairly close to the knees of the operator. When

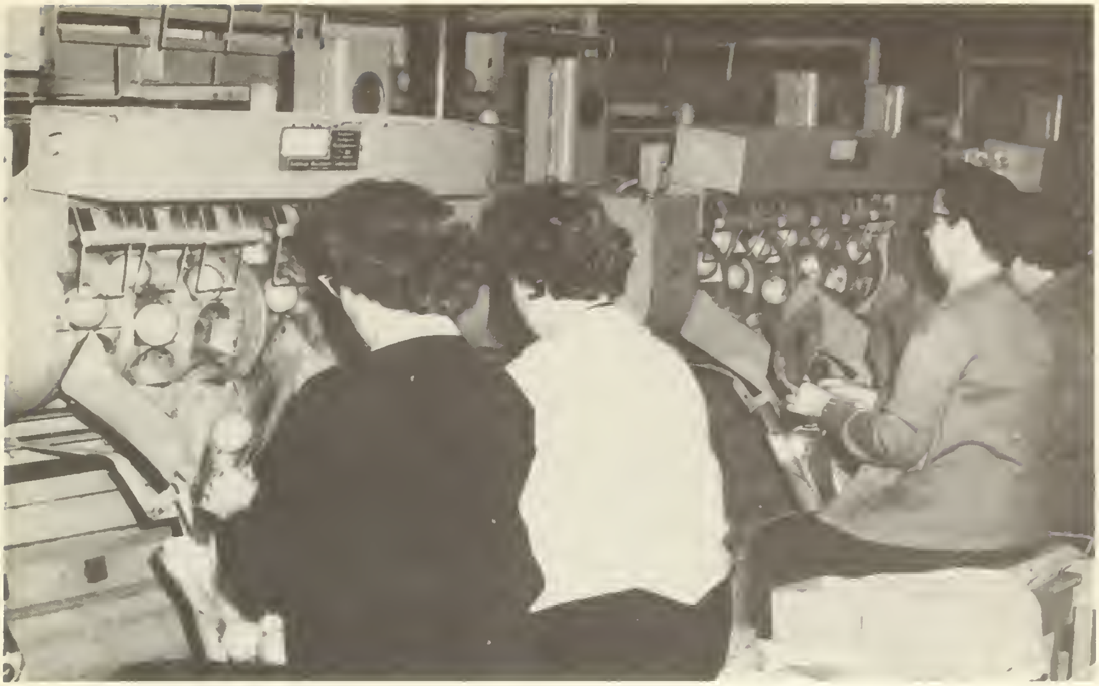

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Figure 3.--Workers seated on stools using count bagging machines. Bag take-away belt is visible below the fruit chute.

a bag was removed from the clamps, the operator set it on the conveyor by holding the top of the bag in one hand, extending her arm down, and releasing the bag.

One worker could fill 380 gusset-type bags per hour with this machine.

Channel-Type Device for Filling Bags

An inexpensive bag-filling unit was developed and put into use by a Florida packinghouse. It was a sloping channel, similar to the rain gutter on a roof, wide enough for a single row of fruit. The channel was installed over a roll-board packing station. The upper end of the channel was fastened to the frame of the return-flow conveyor, and the lower end was supported by the fruit stopboard. Empty bags were placed on top of the roll board adjacent to the bagging unit.

A gate at the upper end of the channel near the return-flow belt controlled the flow of fruit into the channel, and another gate near the lower end held the fruit in the channel. The distance between the two gates could be adjusted, by moving the lower gate, so that the channel when full would hold the correct number of fruit to fill a bag. To get an accurate count of fruit in the channel, the packinghouse resized the fruit on a small sizer similar to the central sizer to reduce the variations in fruit diameter. An additional benefit of resizing was improved weight control of filled bags to prevent overweight bags caused by fruit size variations.

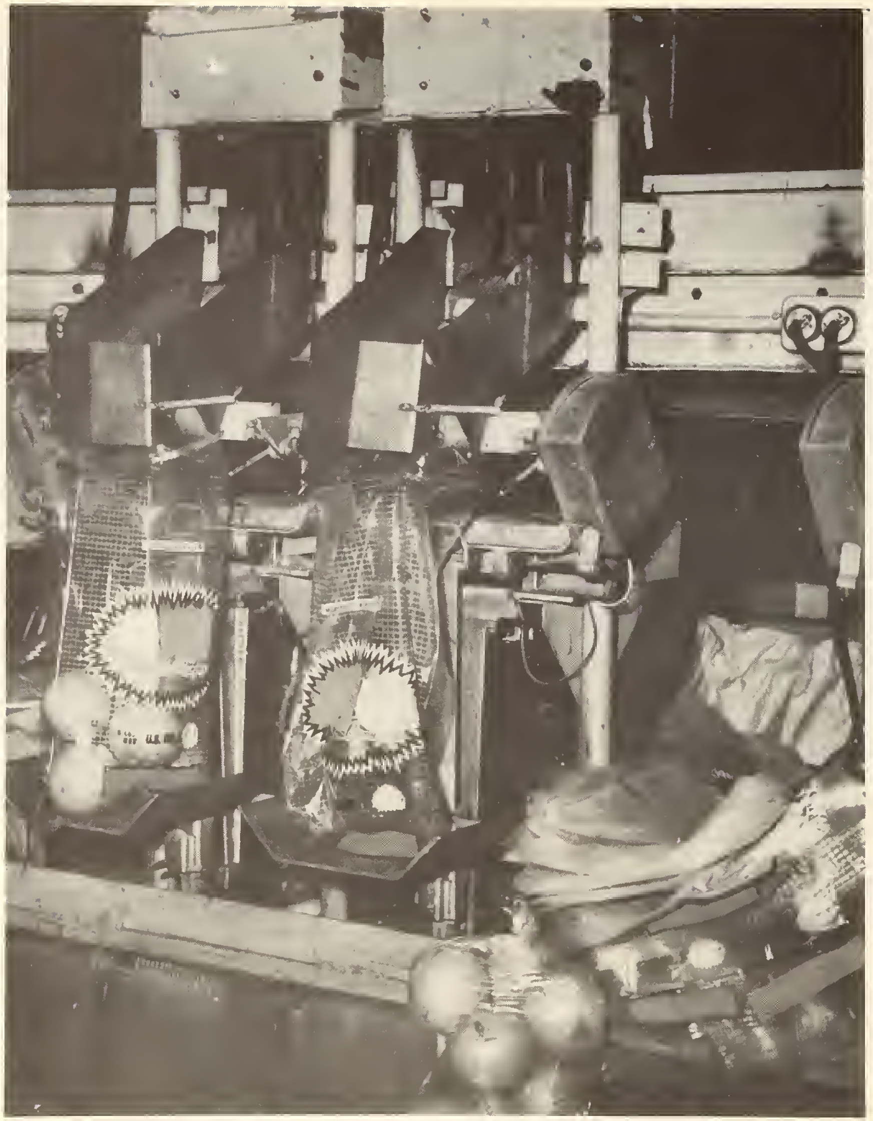

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Figure 4.--This machine filled bags by weight. One worker operated two weighing units. Empty bags were kept in right foreground.

Each worker bagged fruit from two channels, which were mounted side by side. When one channel was filled with fruit, the worker held an empty bag under the end of the filled channel, pressed a lever with thumb and forefinger to open the lower gate and release the fruit, and waited for the fruit to roll down the channel into the bag (fig. 5). When the worker released the lever, the lower gate closed, the gate at the return-flow belt opened, and more fruit rolled into the channel. The worker filled a bag from one channel while the other channel was filling with fruit from the return-flow belt. When a bag was filled, the worker set it on an open-bag conveyor for delivery to a bag-closing machine, picked up an empty bag, and filled it from the full channel.

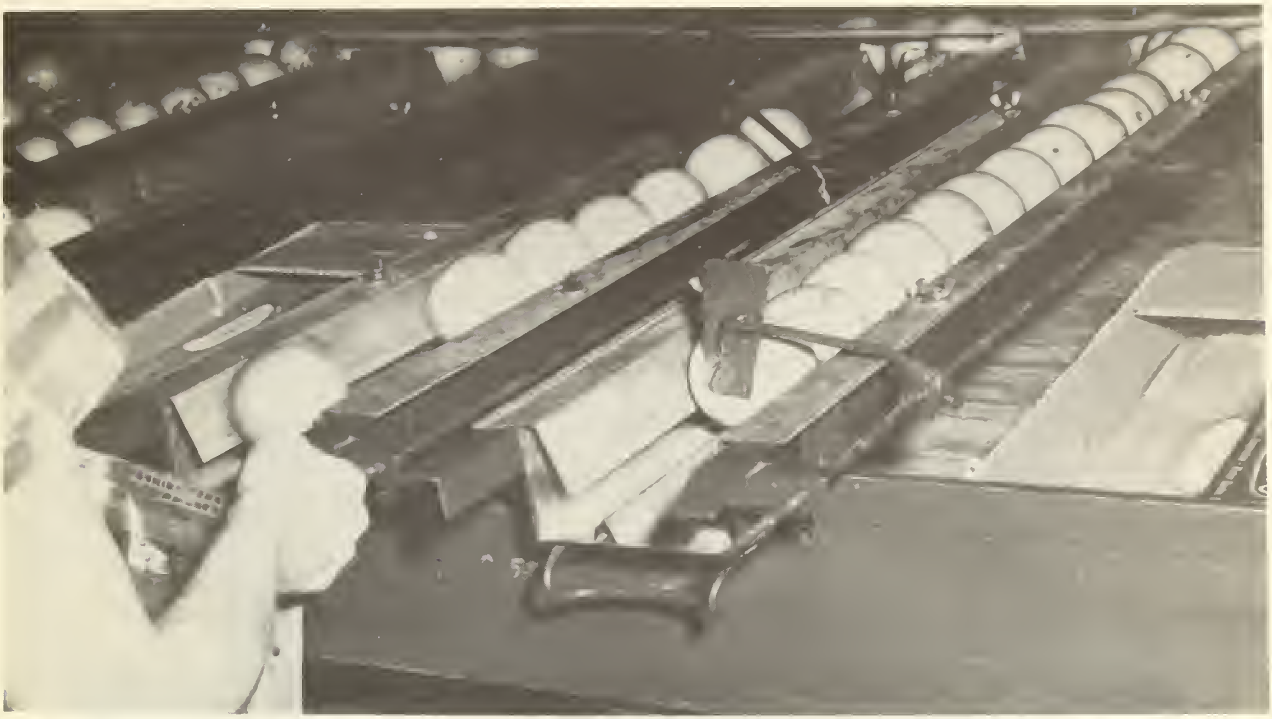

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Figure 5.--Worker filling bag with channel-type bagger.

Since the bagging end of the channel and the open-bag conveyor were not high enough for the operator to work comfortably while standing, stools were provided for the workers. The open-bag conveyor was under the roll board, and the operator could lean forward with a full bag of fruit and set it on the conveyor.

One worker could fill 441 bags per hour with the channel-type bagger when empty bags were stored on top of the roll board adjacent to the bagging unit. A more convenient location for empty-bag storage and other minor changes in the workplace layout could increase the rate of bagging.

Closing Bags

Polyethylene bags, filled by machine, were closed by an automatic taping machine during the studies. Bags were delivered from the filler to the tape machine by an open-bag conveyor belt. The operator of the taping machine grasped the top of the bag and guided it into the tape rolls of the machine. The machine automatically bunched and closed the bag with two pieces of 11/32-inch-wide adhesive tape and dropped them onto another conveyor belt for delivery to the packers of master containers (fig. 6).

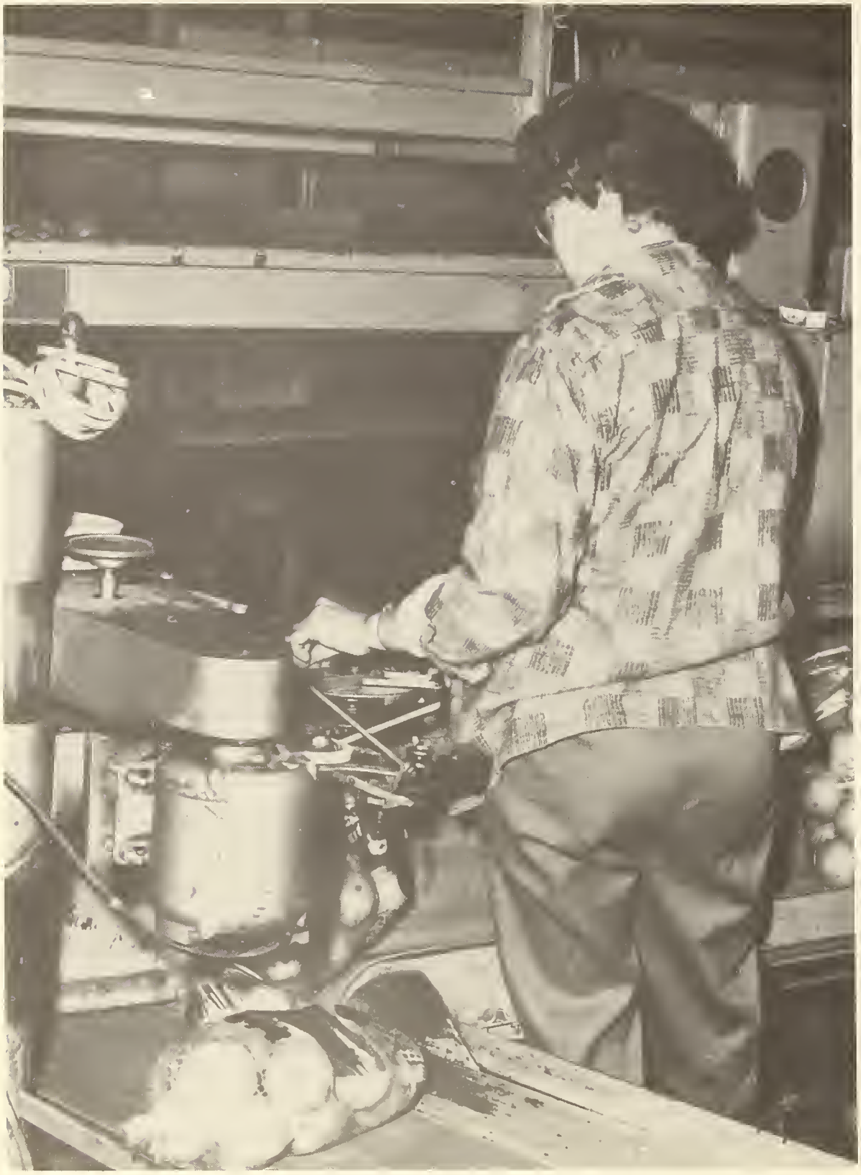

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Figure 6.--Worker closing bag tops with automatic taping machine. The conveyor belt for the closed bags is in the foreground.

One worker operating the taping machine could have closed 2,500 bags per hour if the bags had been available. In most of the crews studied, the bag closer had to wait for bags to be filled. Productive labor for one worker to close 8,000 5-pound bags, sufficient to fill 1,000 master containers, was 3.20 man-hours.

Packing Bags Into Master Containers

The stations that were observed for packing master containers were set between the closed-bag conveyor and the container take-away conveyor. A short section of skate-wheel conveyor was placed at right angles to the two belt conveyors at the same height as the container take-away conveyor. Bags were delivered to the worker at approximately elbow height to permit the worker to lift the bags with minimum effort and drop them into the master container. Empty containers were delivered to the packing stations by an overhead chute located over either the bag conveyor or the container take-away conveyor.

The worker who packed the master container transferred empty containers from the overhead chute to the wheel conveyor. The worker removed one or two bags at a time from the closed-bag conveyor beside him and dropped them into the container (fig. 7). When the container was filled with either eight 5-pound or five 8-pound bags, the packer pushed it onto the take-away belt, which took it to the lid-closing and shipping area, and obtained another container from the chute.

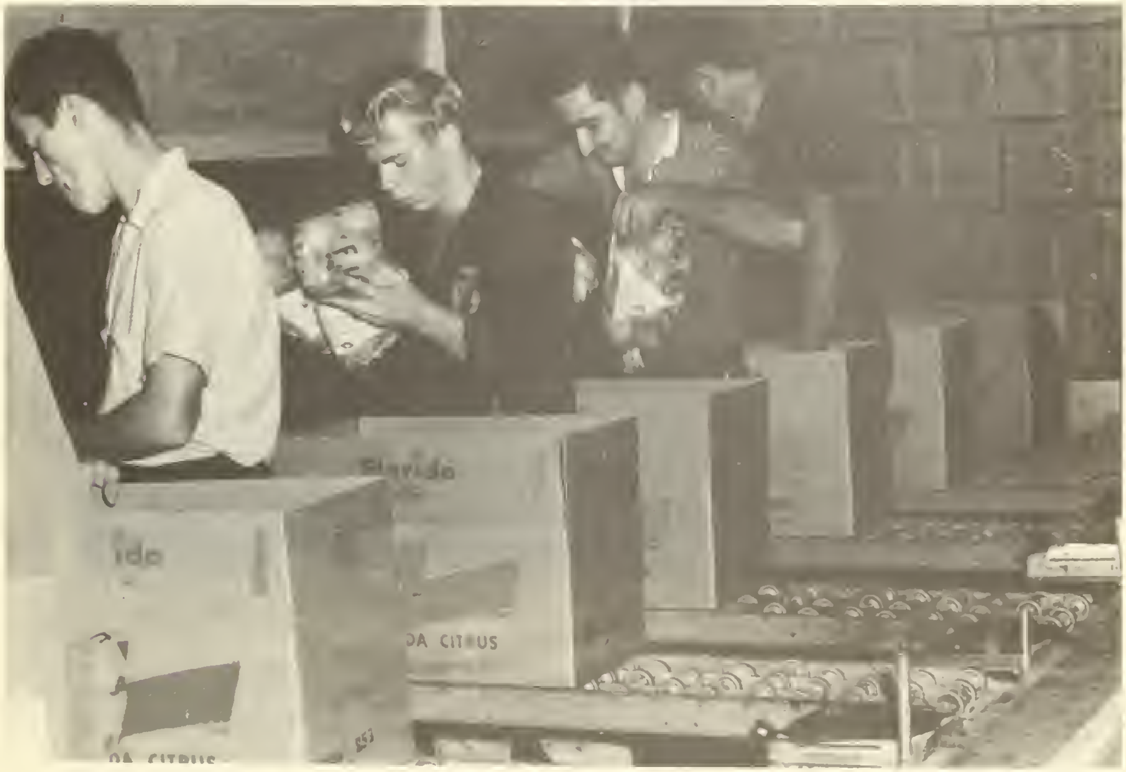

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Figure 7.--Workers packing bags of oranges into master containers.

The belt of the take-away conveyor should be placed high on the frame rails at the packing station. Although guard rails may be used on the conveyor if desired, they should be left off in the packing area. A short vertical rod or roller pivot placed at the edge of the frame of the belt conveyor will turn the filled container onto the belt without the aid of the packer (fig. 8). The worker merely gives the container a shove toward the conveyor belt and turns his attention to getting an empty container for packing. If the belt is low on the conveyor frame rails, the worker must use additional time and effort to manually turn the filled container onto the belt.

Two workers were required to pack bags into master containers for each bag-filling crew. Labor required to pack 1,000 master containers with 5-pound bags was 6.26 man-hours.

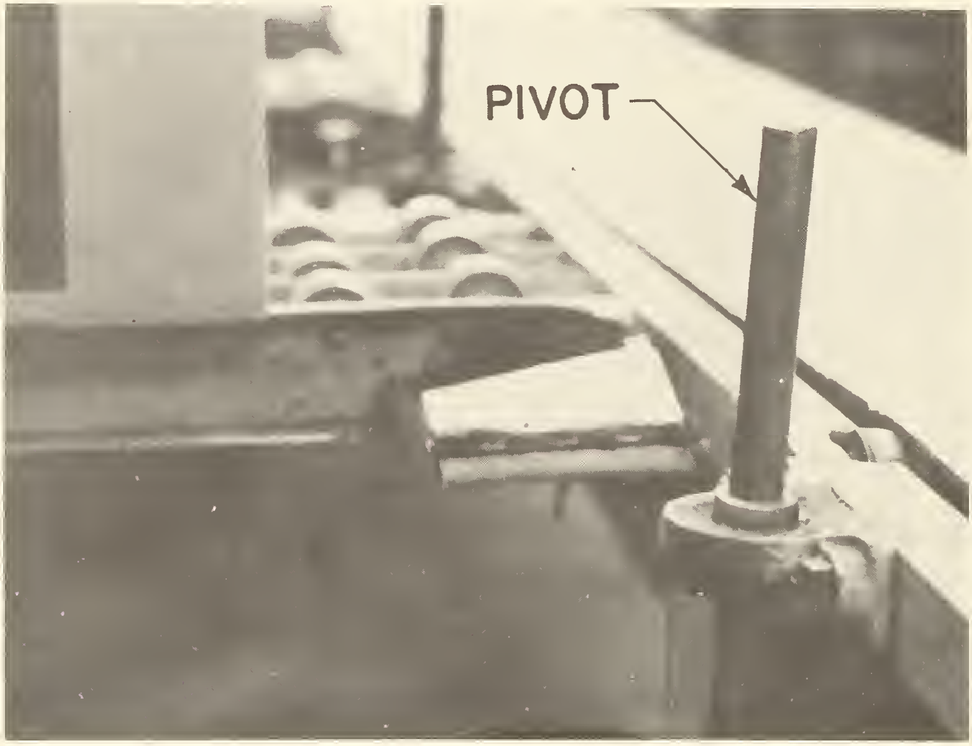

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Figure 8.--A roller pivot to turn filled containers onto the take-away belt conveyor without aid from the packer. Note the belt is located high on the conveyor frame rails.

Labor Requirements and Costs of Bagging Citrus Fruit

Labor requirements for the three mechanical systems of filling bags, including closing the bags and packing them in master containers, are shown in tables 1, 2, and 3.

Table 1.--Electronic counting machine and automatic bag closer: Labor required, per 1,000 master containers, for a 7-man crew to fill 5-pound gusset-type polyethylene bags with size 252 or 125 oranges and pack 8 bags to a container

Time item	Size 252 oranges		Size 125 oranges	
	Crew size	Labor required	Crew size	Labor required
	Workers	Man-hours	Workers	Man-hours
Productive labor:				
Fill bags and set them on conveyor	4	16.00	4	12.80
Close bags	1	3.20	1	3.20
Pack full bags into master containers	2	6.26	2	6.26
Total productive labor		25.46		22.26
Unproductive labor:				
Bag-closer waits for bags	1	.80		
Master container packers wait for bags	2	1.74	2	.14
Total unproductive labor		2.54		.14
Total labor	7	28.00	7	22.40
		Hours		Hours
Elapsed time		4.00		3.20

Table 2.--Machine for filling by weight and automatic bag closer: Labor required, per 1,000 master containers, for a 9-man crew to fill 5-pound gusset-type polyethylene bags with oranges and pack 8 bags to a container

Time item	Crew size	Labor required
	Number	Man-hours
Productive labor:		
Fill bags and set them on conveyor	6	21.06
Close bags	1	3.20
Pack full bags into master containers	2	6.26
Total productive labor		30.52
Unproductive labor:		
Bag-closer waits for bags	1	.31
Master-container packers wait for bags	2	.76
Total unproductive labor		1.07
Total labor	9	31.59
Elapsed time		Hours 3.51

Table 3.--Channel-type device and automatic bag closer: Labor required, per 1,000 master containers, for an 8-man crew to fill 5-pound gusset-type polyethylene bags with oranges and pack 8 bags to a container

Time item	Crew size	Labor required
	Number	Man-hours
Productive labor:		
Fill bags and set them on conveyor	5	18.15
Close bags	1	3.20
Pack full bags into master containers	2	6.26
Total productive labor		27.61
Unproductive labor:		
Bag-closer waits for bags	1	.43
Master-container packers wait for bags	2	1.00
Total unproductive labor		1.43
Total labor	8	29.04
		Hours
Elapsed time		3.63

Labor and equipment costs of bagging by the three mechanical systems and the manual system are shown in table 4. Costs are based on a single bagging crew packing eight 5-pound bags per master container in plants packing 50,000 and 100,000 master containers per year. 3/ Labor costs were based upon a rate of $1.10 per hour, including fringe benefits, for the mechanical bagging systems and a piece-rate pay of 70 cents per 100 bags for the manual bagging system. These costs also assume that a central sizer is used for sizing all fruit whether it is packed in bags or place-packed in boxes. Costs for sizing have not been included in the equipment costs for the bagging systems except when a resizer was required to more accurately size fruit for the channel-type bagging system.

The system with the lowest combined labor and equipment costs depended on the annual volume packed and the number of crews assigned to the bagging operation. 4/ The manual bagging method was the most economical for a single crew when the number of packed containers filled with 5-pound bags was less than 49,900 per year (fig. 9). Channel-type bagging was most economical when the annual volume was between 49,900 and 143,230 master containers, and bagging by count when the volume exceeded 143,230 master containers.

Most citrus packinghouses probably use two or three bagging crews instead of a single crew. When more than one bagging crew is used, the break-even points in the annual volume must be doubled for two crews or tripled for three crews to determine the most economical bagging system.

OPERATING PROBLEMS

In this section of the report, some of the problems associated with mechanical bagging systems are discussed. Management supervision and control of the bagging operation could reduce some of the problems caused by inadequate fruit feed and worker inactivity.

Range in Size of Fruit

Citrus fruits range from 2 inches in diameter for small tangerines to 5-9/16 inches for large grapefruit. This range in size presents a problem for a mechanical system of bag filling. Tangerines present an additional problem by not being spherical and by having flat ends. Grapefruit, especially the larger sizes, present much the same problem as tangerines although probably not to the same extent.

3/ Although tabular information included in the report is restricted to data for 50,000 and 100,000 master containers, costs were also figured for volumes of 25,000 and 200,000 master-container equivalents of packed polyethylene bags. The volumes of 50,000 and 100,000 seemed to be the most representative of the plants studied.

4/ The break-even points in annual volume for the different bagging systems were determined by mathematical equations using variable and fixed costs.

Table 4.--Labor and equipment costs, per 1,000 master containers, for a single crew to fill 5-pound bags with oranges and pack 8 bags to a container

Method of filling bags and size of oranges packed	Crew size	Elapsed time	Labor required	Cost in plant packing 50,000 containers a year			Cost in plant packing 100,000 containers a year		
				Labor 1/	Equipment 2/	Total	Labor 1/	Equipment 2/	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Machine for bagging by count:									
Size 125	7	3.20	22.40	24.64	37.92	62.56	24.64	22.75	47.39
Size 163	7	3.47	24.27	26.70	37.92	64.62	26.70	22.75	49.45
Size 200	7	3.73	26.13	28.74	37.92	66.66	28.74	22.75	51.49
Size 252	7	4.00	28.00	30.80	37.92	68.72	30.80	22.75	53.55
Machine for bagging by weight: all sizes	9	3.51	31.59	34.70	37.42	72.12	34.70	22.58	57.28
Channel-type bagger, all sizes	8	3.63	29.04	31.90	28.32	60.22	31.90	17.15	49.05
Manual, size 200	13	3.57	46.41	3/56.00	4.30	60.30	3/56.00	3.90	59.90

1/ Based on a labor cost of $1.10 per hour, including fringe benefits.
2/ See tables 5-10 in the appendix for ownership and operating costs.
3/ Based on piece-rate pay of 70 cents per 100 bags packed.

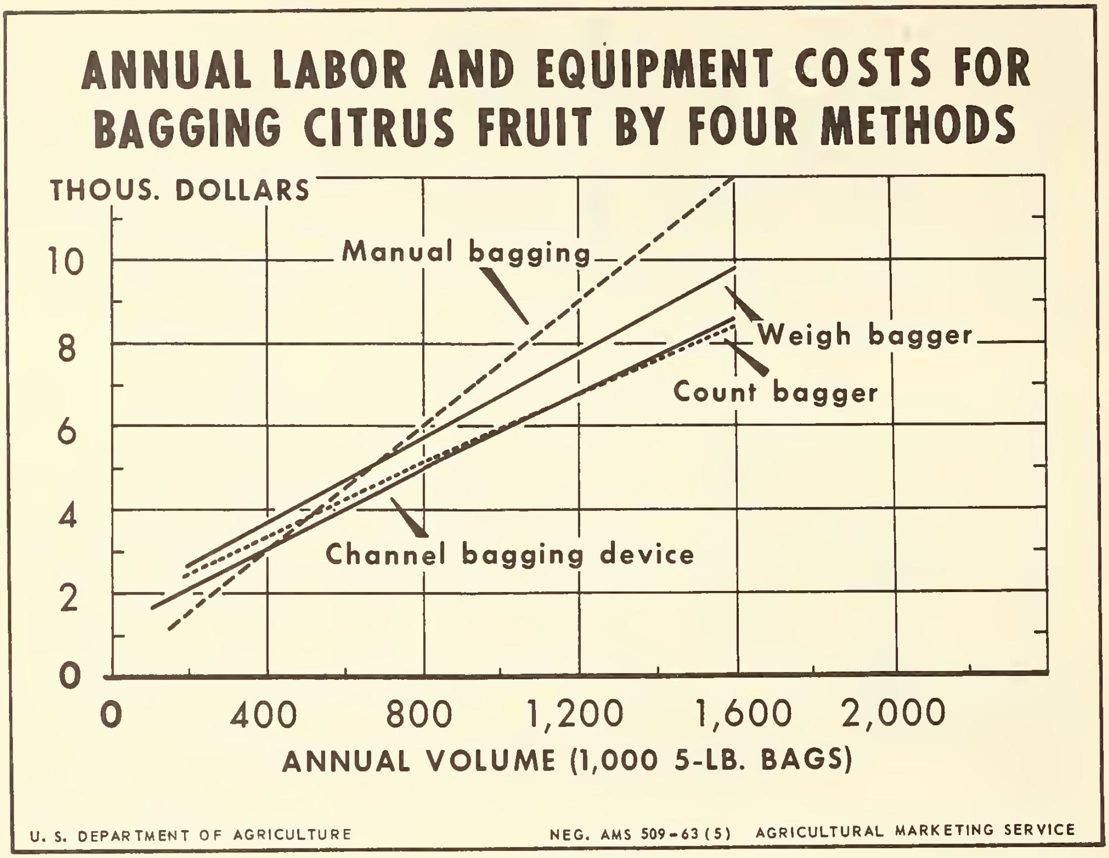

Figure 9.--A packinghouse packing 1,600,000 5-pound bags of oranges a year can save up to $3,525 a year by switching from filling the bags manually to using an electronic bagging machine that counts the oranges.

Of the three types of baggers that were studied, the channel-type is probably the only one that will not easily bag grapefruit or tangerines. Adjustments can be made on the other machines to handle the various sizes and types of fruit, with the possible exception of the larger sizes of grapefruit. This is not a serious problem, however, since the larger sizes of grapefruit are not usually packed in consumer bags.

Type of Bag

Flat bags had a tendency to stick together, and the operator had to spend considerable time separating them before they could be opened and filled. For example, one worker could fill 380 gusset-type bags but only 313 flat bags per hour with the machine for filling bags by weight.

Filling Errors

The machines that counted or weighed the fruit sometimes miscounted or overweighed. Sometimes more than one fruit would feed through the space intended for a single fruit or fruit would fall between the counting levers of adjacent lanes. The weighing machine weighed the fruit that was in the bag. About 67 percent of the time, the bag was overweight because extra fruit fell into the bag while the weighing mechanism was automatically closing the produce door on the return-flow belt. The operator adjusted the bag weights by removing excess fruit.

Fruit Feed

If the speed of the fruit-feed belt is too slow, the supply of fruit to the baggers will not be adequate. Too fast a speed will tend to carry the fruit past the baggers without a sufficient quantity leaving the belt to feed the bagging machines. Wire or rod diverters are mounted over the belt at an angle to the direction of flow. When the flow of fruit hits the diverter, some of the fruit will roll toward the side of the fruit-feed belt and the chute of the bagging machine. If the speed of the belt is too great, many of the fruit will bounce over the diverter and bypass the chute.

Worker Productivity

When the quantity of fruit is insufficient, some of the baggers, the tape-machine operator, and the master-container packers work at less than their capacity. Good supervision and control of the fruit feed can overcome some of this problem.

Even though the flow of fruit is adequate, some workers will have to wait for other members of the crew. Unproductive labor for bagging crews is shown in tables 1 through 3 in a previous section.

RECOMMENDATIONS FOR IMPROVING WORKPLACES

The weight of the 5- or 8-pound bag had no measurable influence on the physical effort of filling bags by any of the bagging methods. A weight exceeding approximately 22 pounds must be handled before fatigue effects on a worker can be measured. 5/ The arrangement of the workplace layout, however, can influence the physical effort required of the worker to bag citrus.

Authorities in the field of motion economy recommend that the height of the workplace and the chair should permit the operator to sit or stand at work. Either sitting or standing for long periods of time produces more fatigue than alternately sitting or standing at will. 6/

5/ Ingenohl, Ingo. Measuring Physical Effort. Jour. Indus. Engin. Vol. X, pp. 99-113, March-April 1959.

6/ Barnes, Ralph M. Motion and Time Study. John Wiley and Sons, Inc. 4th ed. 1958.

An average woman worker holding a bag between her thumb and forefinger can reach 13.6 inches using only her forearm and 25.8 inches with her arm fully extended. 7/ The elbow of the average woman worker will be 40 inches from the floor. The height of the bag holder should then be 40 inches above the floor, and the bag take-away conveyor should be 24 inches above the floor for 8-pound bags and 27 inches for 5-pound bags. A sketch of a worker at a bagging station is shown in figure 10.

7/ See footnote 6.

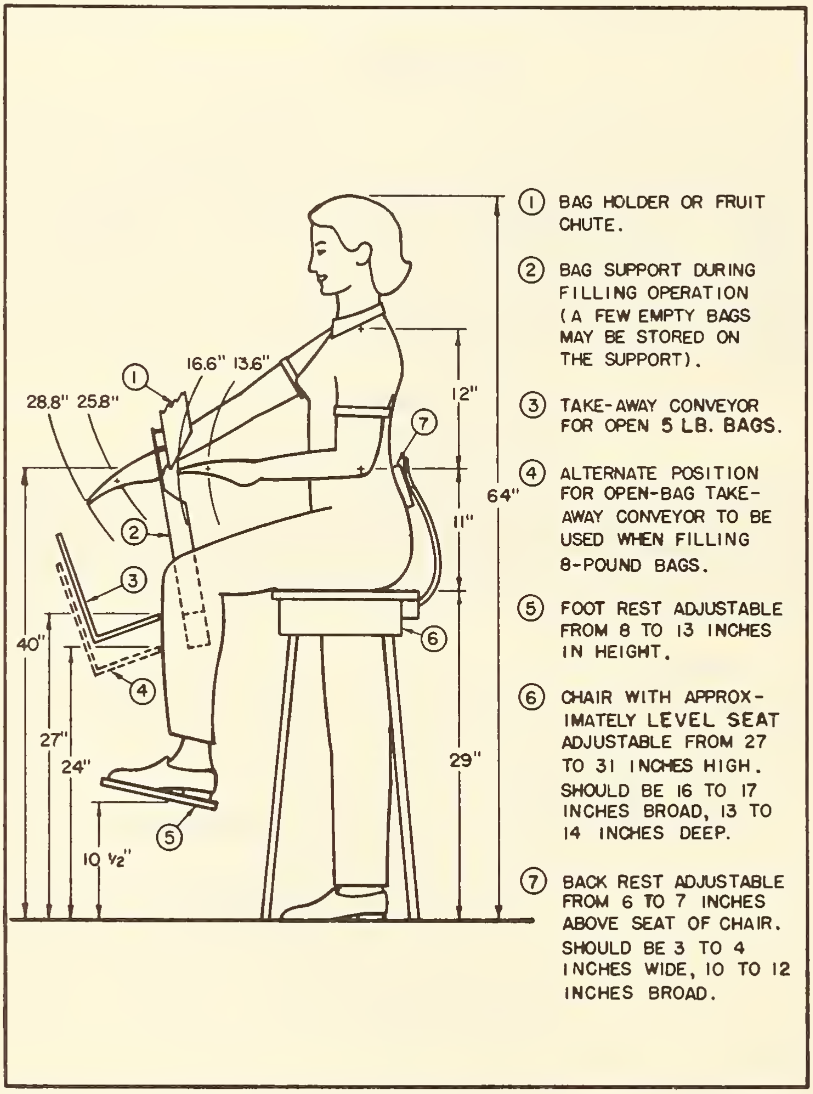
28.8" 25.8"
16.6" 13.6"
12"
11"
64"
40"
27"
24"
10 1/2"
29"
① BAG HOLDER OR FRUIT CHUTE.
② BAG SUPPORT DURING FILLING OPERATION (A FEW EMPTY BAGS MAY BE STORED ON THE SUPPORT).
③ TAKE-AWAY CONVEYOR FOR OPEN 5 LB. BAGS.
④ ALTERNATE POSITION FOR OPEN-BAG TAKE-AWAY CONVEYOR TO BE USED WHEN FILLING 8-POUND BAGS.
⑤ FOOT REST ADJUSTABLE FROM 8 TO 13 INCHES IN HEIGHT.
⑥ CHAIR WITH APPROXIMATELY LEVEL SEAT ADJUSTABLE FROM 27 TO 31 INCHES HIGH. SHOULD BE 16 TO 17 INCHES BROAD, 13 TO 14 INCHES DEEP.
⑦ BACK REST ADJUSTABLE FROM 6 TO 7 INCHES ABOVE SEAT OF CHAIR. SHOULD BE 3 TO 4 INCHES WIDE, 10 TO 12 INCHES BROAD.

Figure 10.--Recommended workplace layout for mechanical bagging units showing height and reach of women workers.

A chair to permit a worker to sit or stand should be adjustable from 27 to 31 inches. The back rest of the chair should be 3 to 4 inches by 10 to 12 inches and adjustable in height from 6 to 7 inches above the seat to fit the worker. The seat of the chair should be level; it should be 16 to 17 inches broad and 13 to 14 inches deep. Both the seat and the back rest should be form fitting and the edges should be rounded. Wooden chairs are more confortable than steel chairs. A foot rest with a slope of 2 inches per 10 inches should be provided. The height of the front edge of the foot rest should be adjustable from 8 to 13 inches.

APPENDIX

Industrial engineering techniques, including time and motion studies, were used to collect and analyze the data. Assumed wage rates were used to convert man-hours of labor to dollar costs and added to these were the costs of ownership and operation of equipment to provide a total cost for the operations.

Equipment Costs

Costs for the equipment described in this report are presented in tables 5-10. Annual ownership and operating costs for the mechanical bagging systems were based on 180 hours of operation in plants packing the equivalent of 50,000 master containers a year and 360 hours in those packing 100,000 containers.

Equipment ownership and operating costs for the manual bagging system are based on the packinghouse operating 1,000 hours annually and packing all types of containers. The percentage of the annual costs charged to bagging was based on the hours the equipment was used for manual bagging operations.

Years of expected life were based on hours of use and obsolescence. Ownership costs were computed using straight-line depreciation over the expected life of the equipment, interest at 5 percent of the average investment, and 4 percent for insurance and taxes.

Labor Requirements

The bagging rate was based on an adequate supply of fruit at the bagging stations. In most packinghouses, there were periods of time during which the bagging workers were required to wait for fruit. Since this time varied in every packinghouse, it was not included in this study of packing methods.

Labor is divided into two classes: Productive and unproductive.

Productive labor is the time, plus certain allowances, required by a qualified and properly trained person working at a normal pace to do the task. Unproductive labor is the time during which the worker is unavoidably delayed in his work and may be caused by (1) an unbalanced workload within the packing

Table 5.--Cost of equipment for packing 50,000 master containers of citrus a year 1/

Equipment	Initial cost per unit	Expected life	Annual ownership costs				Annual operating costs			Total costs
			Depreciation	Interest @5% 2/	Insurance & taxes @4% 2/	Total	Power 3/	Maintenance 4/	Total	
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Return-flow belt:										
18" x 20' 12" x 16'	1,330	13	102.31	35.81	53.20	191.32	9.45	10.00	19.45	210.77
18" x 24' 12" x 20'	1,470	13	113.08	39.58	58.80	211.46	9.53	10.00	19.53	230.99
18" x 29' 12" x 25'	1,650	13	126.92	44.43	66.00	237.35	9.21	10.00	19.21	256.56
Baggers:										
Count	3,050	13	234.62	82.12	122.00	438.74	2.70	75.00	77.70	516.44
Weigh	870	13	66.92	23.42	34.80	125.14	.26	20.00	20.26	145.40
Channel	50	13	3.85	1.35	2.00	7.20	-	1.00	1.00	8.20
Open-bag conveyor:										
16'	1,013	13	77.92	27.27	40.52	145.71	2.70	10.00	12.70	158.41
20'	1,300	13	100.00	35.00	52.00	187.00	4.08	10.00	14.08	201.08
25'	1,625	13	125.00	43.75	65.00	233.75	3.95	10.00	13.95	247.70
Bag closer	2,090	13	160.77	56.27	83.60	300.64	1.35	50.00	51.35	351.99
25' closed-bag conveyor	925	20	46.25	24.28	37.00	107.53	5.40	7.00	12.40	119.93
Skate-wheel conveyor (3' section)	14	13	1.08	.38	.56	2.02	-	.15	.15	2.17
45' container chute	225	15	15.00	6.00	9.00	30.00	-	2.50	2.50	32.50
30' container chute	150	20	7.50	3.94	6.00	17.44	-	.40	.40	17.84
Fruit resizer	1,500	20	75.00	39.38	60.00	174.38	8.17	30.00	38.17	212.55
3 - 20' runout belts	1,500	20	75.00	39.38	60.00	174.38	5.45	11.00	16.45	190.83
15' roll board	375	20	18.75	9.84	15.00	43.59	-	2.00	2.00	45.59
2 - 25' roll boards	1,250	15	83.33	33.33	50.00	166.66	-	40.00	40.00	206.66
Hand taper	25	13	1.92	.67	1.00	3.59	-	.50	.50	4.09
Packing stands	30	15	2.00	.80	1.20	4.00	-	1.50	1.50	5.50
30' fruit-feed belt	950	15	63.33	25.33	38.00	126.66	22.50	30.00	52.50	179.16
25' container take-away conveyor	1,240	15	82.67	33.07	49.60	165.34	30.00	40.00	70.00	235.34

1/ Equipment for count bagging based on 180 hours of annual use; weigh bagging, 175.5 hours; channel bagging, 181.5 hours; manual bagging, approximately 1/6 of 1,000 hours or 178.5 hours.

2/ Interest based on the average investment over the life of the equipment; insurance and taxes based on initial investment.

3/ Based on 3 cents per kilowatt hour.

4/ Estimated annual costs.

Table 6.--Cost of equipment for packing 100,000 master containers of citrus a year 1/

Equipment	Initial cost per unit	Expected life	Annual ownership costs				Annual operating costs			Total costs
			Depreciation	Interest @5% 2/	Insurance & taxes @4% 2/	Total	Power 3/	Maintenance 4/	Total	
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Return-flow belt:										
18" x 20' 12" x 16'	1,330	10	133.00	36.58	53.20	222.78	18.90	15.00	33.90	256.68
18" x 24' 12" x 20'	1,470	10	147.00	40.43	58.80	246.23	19.06	15.00	34.06	280.29
18" x 29' 12" x 25'	1,650	10	165.00	45.38	66.00	276.38	18.43	15.00	33.43	309.81
Baggers:										
Count	3,050	10	305.00	83.88	122.00	510.88	5.40	100.00	105.40	616.28
Weigh	870	10	87.00	23.93	34.80	145.73	.53	30.00	30.53	176.26
Channel	50	10	5.00	1.38	2.00	8.38	-	2.00	2.00	10.38
Open-bag conveyor:										
16'	1,013	10	101.30	27.86	40.52	169.68	5.40	13.00	18.40	188.08
20'	1,300	10	130.00	35.75	52.00	217.75	8.17	13.00	21.17	238.92
25'	1,625	10	162.50	44.69	65.00	272.19	7.90	13.00	20.90	293.09
Bag closer	2,090	10	209.00	57.48	83.60	350.08	2.70	75.00	77.70	427.78
25' closed-bag conveyor	925	15	61.67	24.67	37.00	123.34	10.80	10.00	20.80	144.14
Skate-wheel conveyor (3' section)	14	10	1.40	.39	.56	2.35	-	.20	.20	2.55
45' container chute	225	15	15.00	6.00	9.00	30.00	-	2.50	2.50	32.50
30' container chute	150	15	10.00	4.00	6.00	20.00	-	.60	.60	20.60
Fruit resizer	1,500	15	100.00	40.00	60.00	200.00	16.34	50.00	66.34	266.34
3 - 20' runout belts	1,500	15	100.00	40.00	60.00	200.00	10.90	16.00	26.90	226.90
15' roll board	375	15	25.00	10.00	15.00	50.00	-	3.00	3.00	53.00
2 - 25' roll boards	1,250	15	83.33	33.33	50.00	166.66	-	40.00	40.00	206.66
Hand taper	25	10	2.50	.69	1.00	4.19	-	1.00	1.00	5.19
Packing stands	30	15	2.00	.80	1.20	4.00	-	1.50	1.50	5.50
30' fruit-feed belt	950	15	63.33	25.33	38.00	126.66	22.50	30.00	52.50	179.16
25' container take-away conveyor	1,240	15	82.67	33.07	49.60	165.34	30.00	40.00	70.00	235.34

1/ Equipment for count bagging based on 360 hours of annual use; weigh bagging, 351 hours; channel bagging, 363 hours; manual bagging approximately 1/3 of 1,000 hours, or 357 hours.

2/ Interest based on the average investment over the life of the equipment; insurance and taxes based on initial investment.

3/ Based on 3 cents per kilowatt hour.

4/ Estimate of approximate annual costs.

Table 7.--Annual equipment cost using the count-bagging machine to fill 5-pound bags with 4 sizes of oranges and to pack 8 bags to a master container

Quantity	Item	Cost in plant packing 50,000 containers a year	Cost in plant packing 100,000 containers a year
		Dollars	Dollars
1	Return-flow belt 18" x 20' 12" x 16'....................	210.77	256.68
2	Count baggers................	1,032.88	1,232.56
1	16' open-bag conveyor.........	158.41	188.08
1	Bag closer....................	351.99	427.78
1	25' closed-bag conveyor.......	119.93	144.14
2	3' skate-wheel conveyor.......	4.34	5.10
1	30' container chute...........	17.84	20.60
	Total cost	1,896.16	2,274.94

Table 8.--Annual equipment cost using the weigh-bagging machine to fill 5-pound bags with all sizes of oranges and to pack 8 bags to a master container

Quantity	Item	Cost in plant packing 50,000 containers a year	Cost in plant packing 100,000 containers a year
		Dollars	Dollars
1	Return-flow belt 18" x 29' 12" x 25'	256.56	309.81
6	Weigh-baggers	872.40	1,057.56
1	25' open-bag conveyor	247.70	293.09
1	Bag closer	351.99	427.78
1	25' closed-bag conveyor	119.93	144.14
2	3' skate-wheel conveyor	4.34	5.10
1	30' container chute	17.84	20.60
	Total cost	1,870.76	2,258.08

Table 9.--Annual equipment cost using the channel bagger to fill 5-pound bags with all sizes of oranges and to pack 8 bags to a master container

Quantity	Item	Cost in plant packing 50,000 containers a year	Cost in plant packing 100,000 containers a year
		Dollars	Dollars
1	Return-flow belt		
	18" x 24'		
	12" x 20'	230.99	280.29
5	Channel baggers	41.00	51.90
1	20' open-bag conveyor	201.08	238.92
1	Bag closer	351.99	427.78
1	25' closed-bag conveyor	119.93	144.14
2	3' skate-wheel conveyor	4.34	5.10
1	30' container chute	17.84	20.60
1	Fruit resizer	212.55	266.34
3	20' runout belts	190.83	226.90
1	15' roll board	45.59	53.00
	Total cost	1,416.14	1,714.97

Table 10.--Annual equipment cost using the manual method of filling bags to fill 5-pound bags with size 200 oranges and to pack 8 bags to a master container

Quantity	Item	Cost in plant packing 50,000 containers a year	Cost in plant packing 100,000 containers a year
		Dollars	Dollars
2	30' fruit feed belt	1/ 64.14	2/ 127.92
1	45' container chute	1/ 5.82	2/ 11.60
2	25' roll boards	1/ 36.99	2/ 73.78
13	Hand tapers	53.17	67.47
13	Packing stands	1/ 12.80	2/ 25.53
1	25' container take-away conveyor	1/ 42.13	2/ 84.02
	Total cost	215.05	390.32

1/ 17.9% of total equipment cost charged to bagging operations; 82.1% charged to packing other containers.

2/ 35.7% of total equipment cost charged to bagging operations; 64.3% charged to packing other containers.

crew, (2) crew interference when workers get in the way of each other, (3) machine-regulated wait time, when a machine with a full-time attendant does not provide sufficient productive work to keep the attendant fully occupied, (4) job-regulated wait time resulting from irregular flow of work, (5) waiting for other crews, or (6) time lost by workers changing from one job to another.

For the time study, the operation to be studied was divided into small elements, and each of the elements was timed with a stopwatch. The observed time for a worker to do each element of work was adjusted by a rating factor to a base time so that a qualified worker, working at a normal pace, could easily do the work in the specified time. The rating factor, or leveling as it is sometimes called, was based on the skill of the operator and the effort or speed of movement used by the operator.

Personal and fatigue allowances were added to the base time to obtain productive time. The allowance for personal time was 5 percent of the base time or 3 minutes for each hour of work. Fatigue allowances used in this report were 5 percent of the base time for all work elements and were based on physical effort and working conditions. Some of the factors were complexity of the task, noise, dust, heat, humidity, lighting, weight of the materials handled, and accident hazards.

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